Claims

We claim:

Sub A24

1. A method for evaluating an error-correcting code for a data block of a finite size;

defining an error-correcting code by a parity check matrix;

representing the parity check matrix as a bipartite graph; and

iteratively renormalizing a single node in the bipartite graph until a predetermined threshold is reached.

2. The method of claim 1 wherein the predetermined threshold is a minimum number of remaining nodes.

3. The method of claim 1 wherein the bipartite graph includes variable nodes representing variable bits of the data block, and check nodes representing parity bits of the data block, and the renormalizing further comprises:

selecting a particular variable node as a target node;

selecting a particular node to be renormalized.

4. The method of claim 3 further comprising:

measuring a distance between the target node and every other node in the bipartite graph;

if there is at least one leaf variable node, renormalizing a particular leaf variable node farthest from the target node, otherwise

Sub a24

if there is at least one leaf check node, renormalizing a particular leaf check node farthest from the target node, otherwise

renormalizing a non-leaf variable node farthest from the target node and having fewest directly connected check nodes.

5. The method of claim 1 wherein the bipartite graph is loop-free.

6. The method of claim 1 wherein the bipartite graph includes at least one loop.

7. The method of claim 4 wherein a transmission channel is a binary erasure channel, and further comprising:

decorating the bipartite graph with numbers p_{ia} representing probabilities of messages from variable nodes to check nodes and with numbers q_{ia} representing probabilities of messages from check nodes to variable nodes, and the renormalizing of the non-leaf variable node further comprises:

enumerating all check-nodes a which are connected to the non-leaf variable node;

enumerating all other variable nodes j attached to the check nodes a: and transforming the numbers q_{aj}.

8. The method of claim 7 wherein the transforming of the numbers q_{aj} further comprises:

enumerating all check nodes and variable nodes out to a predetermined distance from the target node;

Sub a24

constructing a logical argument to determine combinations of erasure causing a particular message from the check node a to the variable node j to be an erasure;

translating the logical argument into a transformation for the number q_{aj}.

9. The method of claim 8 further comprising

terminating the renormalizing upon reaching the predetermined threshold by an exact determination.

10. The method of claim 9 wherein the remaining bipartite graph includes N nodes in the exact determination, and further comprising:

converting the decorated graph with numbers q_{ai} and p_{ia} into an erasure graph with an erasure probability x_i with each node i of the bipartite graph;

generating all 2^N possible messages; and

decoding each of the 2^N messages using a belief propagation decoder, where each message has a probability $p = \prod x_i \prod (1 - x_j)$.

11. The method of claim 7 wherein all the numbers q_{ai} are initialized to zero, and all the numbers p_{ia} are initialized to an erasure rate of the transmission channel.

12. The method of claim 7 further comprising:

defining the error-correcting code by a generalized parity check matrix wherein columns represent variable bits and rows define parity bits, and wherein an overbar is placed above columns representing hidden variable bits which are not transmitted; and

representing the hidden variable bits by hidden nodes in the bipartite graph.

Sub a24

13. The method of claim 12 wherein the transmission channel is a binary erasure channel and wherein the error-correcting code is defined by a generalized parity check matrix, and further comprising:

initializing the numbers p_{ia} for hidden nodes i to one.

14. The method of claim 4 wherein the transmission channel is an additive white Gaussian noise channel, and further comprising:

representing messages between nodes in the bipartite graph by Gaussian distributions;

15. The method of claim 1, and further comprising:

selecting a set of criterion by which to evaluate error-correcting codes;

generating a plurality of error-correcting codes;

searching the plurality of error-correcting codes for an optimal error-correcting code according to the set of criterion.

16. The method of claim 15, and further comprising:

evaluating an error rate for each error-correcting code at a plurality of nodes;

generation the optimal error-correcting code according to the evaluated error-rate.

17. The method of claim 1 further comprising:

evaluating an error rate for the renormalized bipartite graph.

add a24